As amended 1984 p.6 p.4

UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF SURVEYING

29.005 SURVEYING 5

Field Exercise: Band Standardisation and Calibration

## 1. AIM

To familiarise students with one technique of standardising a steel band and one technique of determining graduation errors on a 100m steel tape. Use of the "U.N.S.W. Tape Standardisation Baseline" is made and its length established by comparison with a standard tape.

## 2. EQUIPMENT

Per Group:

1 100m steel band (3mm) (Number as per course instruction)
1 thermometer
1 spring balance
1 clip board

Supervisor:

1 100m steel standard tape "APT 3246" on wooden reel
2 10 pound weights
2 5 pound auxiliary weights
1 accessory box containing:
- 3 mercury thermometers
- 1 brush
- 2 magnifying glasses
- 2 cord pulley cylinders
- 1 Allan key for pulley cylinders
- 1 slide for reading 100m end of field tape
- 1 bottle of anti-corrosion fluid (RP7)
- 2 nylon cords with clips (for attachment of weights)
- rags
- cotton waste
- 2 spindles for cord pulleys

## 3. CALIBRATION OF STANDARD BASE

This is done two times per field day as a joint effort of all groups, each time by one half of the number of groups involved in the exercise.

3.1 Attach cord pulley cylinders to spindles and lock them with the Allan key. Fit pulleys into brackets in retaining wall. Prepare reel with 100m steel standard band at "100m" end and unwind carefully along the base, making sure that the band runs over all intermediate supports and does not get caught anywhere. Kinks are definitely to be avoided.

Attach one nylon cord each at both ends to tape, attach one 15 pound weight at the zero end (slowly) and then the other 15 pound weight at the "100m" end. The weights should be lowered slowly and carefully. Adjust length of nylon cords in such a way that standard tape can be moved freely within the full range of the mm scales on the wall brackets. (The ground clearance at the 100m end is rather small). Move cord pulley cylinders horizontally on spindles until tape is aligned vertically and laterally to the scales at the terminal marks.

3.2 The metric graduations at 0m, 25m, 50m, 75m and 100m are fine lines between yellow paint marks. (The red paint marks refer to the imperial markings). The zero graduation applies to both types of marking and is identified by a yellow and red paint patch. Suspend one each of the three mercury thermometers at base height near the "0m", "50m" and "100m" marks. One observer and one booker each is now to be positioned next to the five marks.

3.3 The supervisor will then move the band forward and backward and give a sign when the band marks should be read against the scales at the five baseline marks. Read scale value to 0.1mm. A magnifying glass may be used for this purpose. Read temperature (at 3 stations only) to 0.1$^{o}$C. Book on field sheets provided. See Appendix A for booking and reading example.

3.4 Repeat procedure 3.3 ten times.

3.5 Gently remove weight at "100m end", thus lowering weight at "0m end" to ground. Remove weight and nylon cord at "0m end". With one student holding and following the zero end, attach band to wooden reel and start winding up CAREFULLY. Apply rust-inhibitor solution to band whilst winding. AVOID KINKING under all circumstances.

3.6 Copy measurements in such a way that each group gets a full data set of offsets and temperatures.

## 4. STANDARDISATION OF FIELD BAND

This part of the exercise is executed individually by each group after completion of part 3 of the exercise.

4.1 Calibrate your group's spring balance at 10lbf (pound force = 44.5N) and 15lbf (= 66.7N). Book in field book, including number of spring balance. Determine zero error correction (additive constant) immediately. (The weights of the standard band are used for this purpose).

4.2 Unwind your field band carefully along the ground with the winder at the 100m end (northern end) of the baseline. Carefully lift band onto the intermediate supports by walking from one end to the other. Remove reader and fix terminal loop to the fixed pin at the zero end. (The pin is positioned in such a way that the outer face of the terminal loop is exactly at ±0.0mm on the scale. A band thickness of 0.51mm is assumed. Should the thickness of your terminal loop exceed 0.5mm, get it measured and take the offset into account by computation).

4.3 In case of your band having a terminal loop at 100m, attach terminal loop to pin in slide fitting the 100m base mark bracket. (The graduation line takes account of the "normal" thickness of the band, 0.51mm. See 4.2 for more details). Attach spring balance. Should your band feature a brass leaf at "100m", attach spring balance to the end of the band.

4.4 Position thermometers and bookers/observers at the 0m, 50m, 100m marks. Pull band with 70N and, at the time of a signal, read 50m and 100m marks against the scales on the wall brackets. Read to 0.1mm. Read temperatures to 0.1$^{o}$C. (At the zero end, only temperature is measured). Book in field book. The readings on the scales are again in terms of "LEFT" (north) and "RIGHT" (south) of origin.

4.5 Repeat procedure 4.4 four times with ease of tension in between.

4.6 Unhook band at zero end and lower band to ground. Wind up after having attached reader.

## 5. DETERMINATION OF GRADUATION ERRORS

This part of the exercise is carried out by each group separately. (On any one day, half of the groups start with this part of the exercise).

5.1 Locate one of the auxiliary scales in the field. (The location of these scales will be indicated during the briefing). The auxiliary scale is defined by the centre graduation lines on two short sections of tape glued onto a concrete bench or wall. It is approximately 10m long.

5.2 The HANSEN method is used for the determination of the graduation errors. Make sure that the band mark with the lower reading is always on the same side of the observers (usually LEFT of the observer). The intervals 0-10, 10-20, ... 80-90, 90-100m are tested eight times each at 70N.

5.3 Hold zero end of band (~~outer~~ inner face of outer terminal loop) somewhere on the piece of tape being the left end of the auxiliary scale. Apply tension (at the right end) with spring balance (70N) and read simultaneously the band marks against the mm-scales on the two pieces of tape. Read in terms of "left" (L) and "right" (R) from the centre line on the auxiliary scale marks and read to 0.1mm. Record temperature. (The thermometer should have same contact with ground and same exposure to sun as band). See Appendix B for principle of reading against auxiliary scale.

5.4 Relax tension, shift zero end of band a bit (remaining within the bounds of the mm-graduations of the auxiliary scale), and repeat 5.3.

5.5 Repeat 5.4 another six times, giving a total of eight observations for the interval 0-10m.

5.6 Repeat programme 5.3 to 5.5 for band intervals 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100.

## 6. REPORT

Group reports are requested. Submission: two weeks after practical.

6.1 Compute the distances on the tape standard base between the zero and the four marks at 25m, 50m, 75m, 100m on the field sheet provided. See also Appendix A. The 100m steel standard band "APT 3246" has the following specifications:

Width 3.175mm (1/8 inch)
Thickness 0.508mm (1/50 inch)
Unit weight 0.01220 kg/m
Coefficient of linear expansion $11\times10^{-6}/^{o}C$ (assumed)

The 100m steel standard band "APT 3246" was standardised by the National Measurements Laboratory (C.S.I.R.O.) at 15lbf (66.72N) at $20.0^{o}C$ in March, 1969 and at full support.

| INTERVAL | LENGTH OF BAND APT 3246 (m) | ASSOCIATED UNCERTAINTY (m) |
|---|---|---|
| 0-25 | 24.999 5 | ±0.00025 |
| 0-50 | 49.999 7 | ±0.00050 |
| 0-75 | 74.999 7 | ±0.00075 |
| 0-100 | 99.999 6 | ±0.00100 |

All measurements were made to the centres of the graduation lines on that part of the line within approximately 0.3mm off the graduated edge of the tape. The uncertainties quoted above have been estimated on the basis that there was not more than one chance in one hundred that any value given departed from the true value by more than the stated uncertainty.

6.2 Compute the standard deviations and 99 percent confidence intervals for the reduced means of the measurements at 25m, 50m, 75m, 100m. Considering the stated uncertainties in 6.1 (for the 100m steel standard band), the uncertainty of the "mean reduced scale reading" and an (assumed) uncertainty of the mean temperature reading of ±0.5°C (99 percent confidence interval), compute the 99 percent confidence intervals of your "distances between zero graduations on scale", viz. your values of the U.N.S.W. Tape Standardisation Baseline.

6.3 Discuss the effect of sag on the determination of the baseline distances. The standard band was calibrated when fully supported. On the U.N.S.W. Tape Standardisation Baseline, however, the band is supported at approximately 3.0m intervals.

6.4 From your measurements in section 4, compute the standard temperatures for the intervals 0-50m and 0-100m separately. Applying the propagation law of variances, compute the 99 percent confidence intervals for the two standard temperatures determined. Compute then a weighted "mean standard temperature" and its associated 99 percent confidence interval.

6.5 From the measurements executed whilst following the instructions of section 5:

- compute the mean $\bar{a}$ for all 10 intervals;
- compute graduation errors X, following HANSEN's method;
- compute the standard deviations of all ten $\bar{a}$;
- compute a pooled standard deviation of one $\bar{a}$;
- compute the standard deviation of the graduation error of the 50m mark ($X_{50}$); of 10m/90m mark, of 20m/80m mark, of 30m/70m mark and of 40m/60m mark.
- compute the 99 percent confidence intervals of $X_{50}$, $X_{10,90}$, $X_{20,80}$, $X_{30,70}$, $X_{40,60}$.

6.6 Determine a measure for the "overall accuracy" of your 100m steel band. Discuss this value in detail.

6.7 Plot graduation errors (y-axis) versus distance (x-axis) and comment on trends. Add error band of graduation errors.

6.8 Apply the correction to the measurements executed at 50m on the U.N.S.W. Tape Standardisation Baseline which is necessary to compensate for the graduation error at 50m. Compute a new standard temperature for the 0-50m interval and its associated 99 percent confidence interval. Comment on the result and compare with the standard temperature of the 0-100m interval. Is the difference between both values (statistically) significant?

NOTE: Follow instructions given in handbout "Submission of Reports" closely. Sections 6.1-6.7 refer to the "body of the report" only.

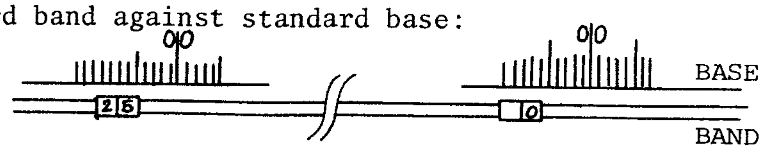
J. M. RÜEGER,
Senior Lecturer.

April, 1983.

## APPENDIX A

* Example of reading standard band against standard base:

e.g. Observation No. 9
(see below)




* Example of reduction of standard band readings:

SCALE READINGS:

R = RIGHT; L = LEFT

| | 25m | | | | 0m | | |
|---|---|---|---|---|---|---|---|
| No. | Red. | | Obs. | | Red. | Obs. | |
| 1 | R | 0.9 | R | 1.2 | 0 | R | 0.3 |
| 2 | R | 1.0 | R | 9.0 | | R | 8.0 |
| 3 | R | 0.9 | R | 13.9 | | R | 13.0 |
| 4 | R | 0.7 | R | 20.4 | | R | 19.7 |
| 5 | R | 0.9 | R | 31.0 | | R | 30.1 |
| X 6 | R | 0.8 | ~~R~~L | 29.2 | | L | 30.0 |
| X 7 | R | 0.9 | ~~R~~L | 22.1 | | L | 23.0 |
| X 8 | R | 1.0 | ~~R~~L | 15.9 | | L | 16.9 |
| X 9 | R | 1.0 | ~~R~~L | 7.1 | | L | 8.1 |
| X 10 | R | 1.0 | ~~R~~L | 1.1 | 0 | L | 2.1 |
| Mean | R 0.9mm | | | | 0 mm | | |

| Field Temperature | Standard Temperature |
|---|---|
| 18.0°C | 20.0°C |

Correction for temperature =

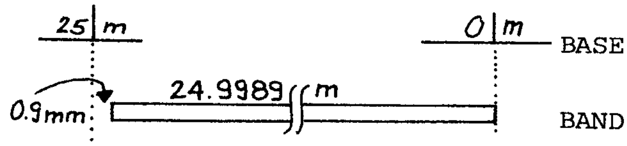
$L\,\alpha(t_F - t_s)$

$= 25 \times 11.0 \times 10^{-6}\ (18-20)$

$= -0.0006$m

@ 20°C 0-25 on std. tape = 24.999 5m

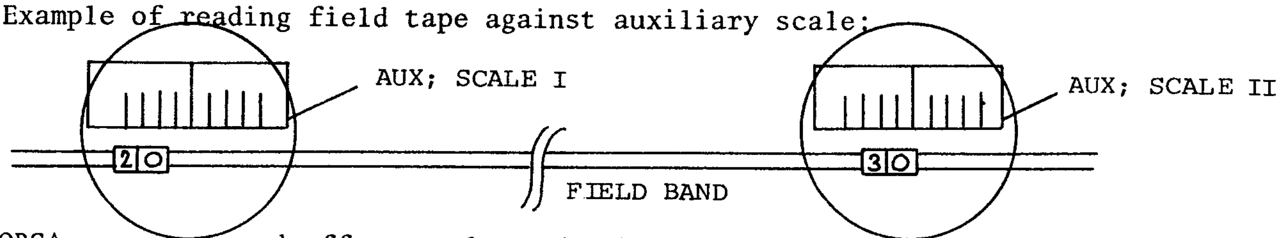
@ 18°C 0-25 on std. tape = 24.998 9m




i.e. Distance between zero marks on
0 & 25m scales = 24.999 8m.

## APPENDIX B

* Example of reading field tape against auxiliary scale:




$OBS\Delta_I$ = measured offset at lower band mark (left end of aux. scale)

$OBS\Delta_{II}$ = measured offset at higher band mark (right end of aux. scale)

Measured: $\Delta_I$ = L 3.2mm

$\Delta_{II}$ = L 1.7mm

RED(uced) $\Delta_{II}$ = $OBS\Delta_{II} - OBS\Delta_I$

= L 1.7mm - L 3.2mm

= R 1.5mm

With R = +; L = - $\Delta$ = +1.5mm

and $a$ = $-\Delta$

$a_{20-30}$ = -1.5mm

SCHOOL OF SURVEYING

# CALIBRATION OF UNSW STANDARD BASE
## OBSERVATION SHEET

Stan. Tape * APT 3246

Date:
Supervisor:
Subject:
Group(s):

| FIELD TEMPERATURE at | | |
|---|---|---|
| 100m | 50m | 0 m |
| | | |
| Mean Temp: | | |

SCALE READINGS **

| No. | 100 m | | 75 m | | 50 m | | 25 m | | 0 m | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Red. | Obs. | Red. | Obs. | Red. | Obs. | Red. | Obs. | Red. | Obs. |
| | | | | | | | | | 0.0 | |
| | | | | | | | | | | |
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| | | | | | | | | | | |
| | | | | | | | | | 0.0 | |
| Mean | | mm | | mm | | mm | | mm | 0.0 | mm |

$C_T$ per 25 m per $^oC = 0.00028(t_F - 20) =$ m

** Consider Mean Reduced Scale Readings as +ive Right
-ive Left

| Length of Standard Tape at Field Temperature | | + Mean Reduced ** Scale Reading | | Distance Between Zero Graduations on Scale | |
|---|---|---|---|---|---|
| $l_{0-25} = 24.9995 + C_T$ | = | | = | m | 0-25 m |
| $l_{0-50} = 49.9997 + 2C_T$ | = | | = | m | 0-50 m |
| $l_{0-75} = 74.9997 + 3C_T$ | = | | = | m | 0-75 m |
| $l_{0-100} = 99.9996 + 4C_T$ | = | | = | m | 0-100 m |

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